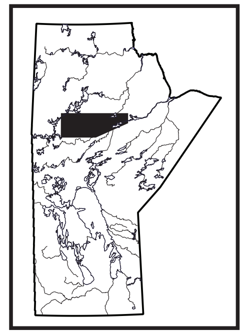
GS-10

Granitoid rocks in north-central Manitoba: preliminary results of reconnaissance mapping and sampling

by X.M. Yang



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Summary

In 2016, the Manitoba Geological Survey continued its project to investigate the petrogenesis and metallogeny of granitoid rocks throughout Manitoba. Initiated in spring of 2014, the main objectives of this project are to identify the various petrogenetic types of granitoid rocks in Manitoba and to investigate their geodynamic settings and mineralization potential. This report presents the preliminary results of fieldwork conducted in north-central Manitoba. Granitoid rocks were examined and sampled to document field relationships, textures (fabrics), mineral assemblages, magnetic susceptibilities (MS) and presence of mineralization and/or alteration.

This study indicates that muscovite- and/or garnet-bearing granitic rocks characterized by very low MS values (<0.1 × 10^{-3} SI units; i.e., strongly peraluminous S-type or ilmenite-series) were intruded mainly into domain boundaries, which may thus serve as a useful criterion for recognizing major tectonic or domain boundaries (or crustal-scale discontinuities). These peraluminous granitic rocks may have formed in crust thickened as a result of terrane assembly and/or continental collision, and may have potential to host rare-metal and/or Sn-W mineralization. In contrast, plutons consisting of quartz monzonite, granodiorite and granite are characterized by higher MS values (>0.1 × 10^{-3} SI units) and mineral assemblages typical of I-type, or magnetite series, granitoid rocks (e.g., hornblende±biotite or biotite±hornblende). Such plutons are abundant across the region, suggesting that this magmatism contributed significantly to crustal growth in the Trans-Hudson orogen, largely related to subduction tectonics. It is worth noting that normal I-type granitoid intrusions may have potential to host porphyry Cu, Au and Mo mineralization. Evolved I-type granitoid intrusions in the region, despite being subordinate in volume, may have potential to host rare-metal (e.g., Nb, Ta) mineralization.

Introduction

Granitoid rocks are the most abundant rock type in the Canadian Shield, including north-central Manitoba (Gilbert et al., 1980; Manitoba Energy and Mines, 1986; Baldwin et al., 1987; Hollings and Ansdell, 2002; Beaumont-Smith and Böhm, 2004). These rocks often preserve primary geochemical signatures that can be used to constrain their petrogenesis, sources, tectonic settings and mineral potential. I-type granite, originating from igneous sources (Chappell and White, 1974, 1992, 2001), usually displays oxidized features with high MS values, consistent with magnetite-series granite (Ishihara, 1977, 1981, 2004), and may have potential for Cu-Mo-(Au) mineralization (Blevin and Chappell, 1995; Blevin, 2004). In contrast, S-type granite, sourced from sedimentary rocks (Chappell and White, 1974, 1992, 2001), commonly exhibits reduced features and low MS values, consistent with ilmenite-series granite (Ishihara, 1977, 1981, 2004), and is commonly related to Sn-W and rare-metal (e.g., Nb, Ta, rare-earth elements, Y) mineralization (Blevin, 2004). Furthermore, alkaline A-type granite, formed in anorogenic tectonic settings, is usually characterized by relatively oxidized features and may have potential for generating rare-metal minerals (e.g., Whalen et al., 1987; Winter, 2009). Such generalizations can be useful in mineral exploration. There are some exceptions to these generalizations, however, such as reduced I-type ilmenite-series granitic rocks that are potentially associated with intrusion-related Au mineralization (Lang and Baker, 2001; Blevin, 2004; Yang et al., 2008).

This report presents the preliminary results of reconnaissance mapping and sampling of granitoid rocks in the Leaf Rapids and Kisseynew domains, and the Superior boundary zone in north-central Manitoba. Petrographic examination and whole-rock geochemical analysis of 30 samples collected in 2016 are ongoing and will be reported in a future publication.

Methods

Granitoid rocks were examined and sampled in the field to document field relationships, textures (fabrics), mineral assemblages, magnetic susceptibilities (MS) and presence of mineralization and/or alteration. A Terraplus Inc. KT-10 magnetic-susceptibility meter was used with a pin to measure MS values of glaciated outcrops and fresh exposures in roadcuts or quarries (note that the measurement range is 0.001–1999.99 × 10^{-3} SI units); each rock type was measured in at least five locations and the average of the measurements was recorded to represent the MS value. Outcrops were sampled using a rock saw or sledgehammer for laboratory study. The MS values were used to distinguish relatively oxidized and reduced granitoid rocks and, together with their mineral assemblages, to classify the petrogenetic type of granitoid rock. A compilation of the main characteristics of I- and S-type granitoid rocks, including magnetite- and ilmenite-series, for the granitoid rocks in southeastern Manitoba and elsewhere can be found in Yang (2014).

Geological setting

North-central Manitoba is underlain by dominantly granitoid rocks in varied tectonic units, including the Leaf Rapids, Southern Indian and Kisseynew domains, and the Superior boundary zone. The latter can be further divided into domains (e.g., Thompson, Split Lake and Assean Lake domains; Figures GS-10-1, -2). The Leaf Rapids domain is comparable to the Lynn Lake domain to the west (lithostratigraphic and temporal links have been established by several authors; e.g., Rayner and Corrigan, 2004; Corrigan et al., 2007, 2009), which is well known for its endowment in orogenic Au, magmatic Ni-Cu and volcanogenic Cu-Zn deposits (Beaumont-Smith and Böhm, 2002, 2004). Together they constitute an important tectonic element of the Reindeer zone of the Trans-Hudson orogen (Stauffer, 1984; Hoffman, 1988; Lewry and Collerson, 1990; Zwanzig et al., 1999; Zwanzig and Bailes, 2010). The Lynn Lake–Leaf Rapids domain is bounded to the north by the Southern Indian domain (a mixed metasedimentary and metaplutonic domain) and the Chipewyan domain (a continental-arc granitoid batholith); to the south, it is bounded by the metasedimentary Kisseynew domain; and to the east it is flanked by the Superior boundary zone (Figure GS-10-1; Gilbert et al., 1980; Syme, 1985; Böhm et al., 1999, 2003; Zwanzig et al., 1999, 2001, 2003; White et al., 2002; Corrigan et al., 2007, 2009; Zwanzig and Bailes, 2010).

Field descriptions of granitoid rocks

The locations of granitoid plutons or intrusions described in this report are shown and numbered in Figure GS-10-2. The main features of these granitoid plutons are summarized in this report, progressing in general from the Leaf Rapids area to the Split Lake area. A summary of features of these granitoid rocks is presented in Table GS-10-1.

Granitoid rocks in the Leaf Rapids domain

Three granitoid plutons in the Leaf Rapids domain (LRD) were examined and sampled (Figure GS-10-2, Table GS-10-1): the Issett Lake pluton (locality 1; Yang and Beaumont-Smith, 2015), Ruttan Lake pluton (locality 2) and Turnbull Lake pluton (locality 3). These plutons are parts of the large Baldock batholith (Baldwin et al., 1987). Note that the LRD is comparable to the Lynn Lake domain in terms of lithostratigraphy and geochronology (Figure GS-10-1; Rayner and Corrigan, 2004; Corrigan et al., 2007, 2009; Zwanzig and Bailes, 2010).

Issett Lake pluton (locality 1)

The Issett Lake pluton is a composite pluton emplaced into the boundary between the LRD and the Southern Indian domain (Figure GS-10-2). This pluton consists of garnet-muscovite granite that intrudes strongly

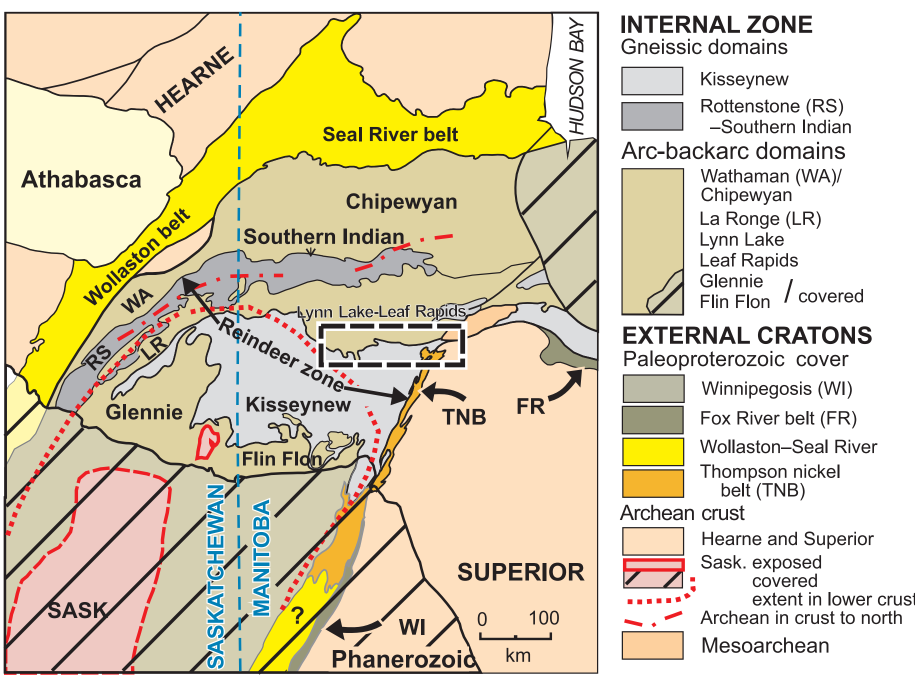

***Figure GS-10-1**: Simplified geology of the Trans-Hudson orogen in Manitoba and northeastern Saskatchewan, showing the major lithotectonic domains of the internal (Reindeer) zone of the Trans-Hudson orogen, Archean cratons and their Paleoproterozoic cover (external zones; after Zwanzig and Bailes, 2010). Dashed outline indicates location of Figure GS-10-2.*

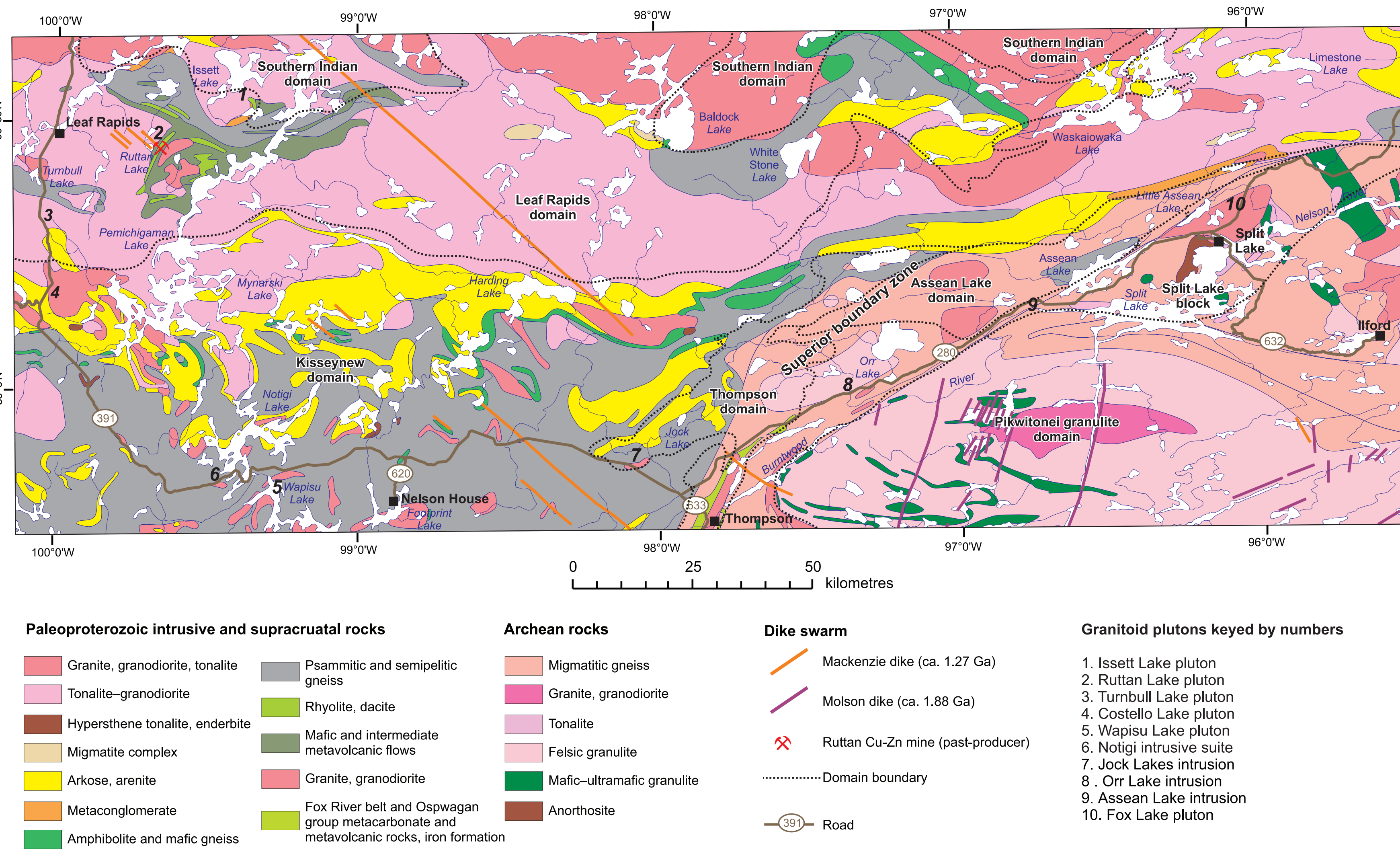

Figure GS-10-2: *Simplified geology of north-central Manitoba, showing the dominance of granitoid rocks in tectonic units that include the Southern Indian, Leaf Rapids (Lynn Lake) and Kisseynew domains, and the Superior boundary zone (SBZ) that includes the Thompson, Split Lake and Assean Lake domains. Numbered granitoid plutons or intrusions examined in this study are referred to in the text. Nomenclature of tectonic units or domains is modified from Manitoba Energy and Mines (1986), Zwanzig et al. (2001) and Zwanzig and Bailes (2010).*

Table GS-10-1: Main features of granitoid rocks in the various tectonic units of north-central Manitoba.

Tectonic unit	Intrusion Name	No.[(1)]	MS (x 10^{-3} SI)	Index minerals	Petrogenetic types
Leaf Rapids domain (LRD)	Issett Lake pluton	1	0.046-0.064	Biotite, muscovite, ±garnet	Ilmenite-series, S-type
		1	0.215-10.1	Hornblende, biotite	Magnetite-series, I-type
	Ruttan Lake pluton	2	2.44-10.6	Hornblende, biotite	Magnetite-series, I-type
	Turnbull Lake pluton	3	7.09-18.2	Hornblende, biotite	Magnetite-series, I-type
Kisseynew domain (KD)	Costello Lake pluton	4	9.70-26.7	Hornblende, biotite	Magnetite-series, I-type
	Wapisu Lake intrusion	5	0.046-0.079	Garnet, bitotite, ±muscovite	Ilmenite-series, S-type
	Notigi Lake intrusive suite	6	0.038-0.43	Garnet, bitotite, ±muscovite	Ilmenite-series, S-type
Superior boundary zone (SBZ)	Jock Lake intrusion	7	0.048	Garnet, muscovite	Ilmenite-series, S-type
	Orr Lake intrusion	8	0.716-11.9	Hornblende, biotite	Magnetite-series, I-type
	Assean Lake intrusion	9	0.165-3.4	Biotite±hornblende	Magnetite-series, I-type
	Fox Lake pluton	10	0.088	Biotite	Ilmenite-series, S-type?

(1) Number labelled in Figure GS-X13-2
Abbreviation: MS, magnetic susceptibilty

foliated tonalite (not included in this report; for detailed description, see Yang and Beaumont-Smith, 2015); biotite-muscovite granite (or two-mica granite) intruding gneissic metasedimentary rocks (biotite+plagiocloase+ quartz±garnet); and granodiorite cutting metavolcanic to metavolcaniclastic and metasedimentary rocks. The field relationships and deformation fabrics reveal that the garnet-muscovite granite and two-mica granite are younger than the moderately to strongly foliated tonalite and granodiorite.

The biotite-muscovite granite is light grey on fresh surface and weathers pale white. It is fine to medium grained, massive and equigranular. This granite cuts sulphide-bearing gneissic metasedimentary rock and locally contains xenoliths of the metasedimentary rock that are rich in biotite and porphyroblastic garnet (Figure GS-10-3a, b). This granite consists of 2–4% biotite (1–1.5 mm), 30–35% anhedral quartz (0.4–1.5 mm), 50–55% whitish-cream to light grey feldspar laths (1–3 mm) and minor muscovite flakes (0.2–0.5 mm). Locally, trace disseminated pyrrhotite (0.1–0.3 mm) is evident and shows weakly magnetic, indicative of a monoclinic variety formed at low temperature. This granite has very low MS values of 0.046–0.064 ×10^{-3} SI. The MS feature, together with the mineral assemblage, indicates that this two-mica granite belongs to the S-type (Chappell and White, 1974, 1992, 2001) and ilmenite-series granites (Ishihara, 1977, 1981, 2004).

The granodiorite from the Issett Lake pluton is moderately foliated, medium to coarse grained, equigranular and locally porphyritic. It is pinkish grey on fresh surface and locally contains mafic inclusions (or aggregates) and mafic metavolcanic rock xenoliths. This granodiorite consists of 10–15% hornblende (5–15 mm), 2–3% biotite (2–4 mm), 20–25% quartz (1–4 mm), 30–35% subhedral to anhedral plagioclase (up to 1.3 cm) with diffuse grain boundaries, 15–20% K-feldspar (0.5–15 mm) and minor magnetite (Figure GS-10-3c). Locally, fine-grained hornblende aggregates up to 5 cm are evident. Aplite dikes up to 10 cm thick cut the granodiorite. Compared to the biotite-muscovite granite described above, this granodiorite shows higher MS values, ranging from 0.215 to 10.1 × 10^{-3} SI, consistent with normal I-type (Chappell and White, 1974, 1992, 2001) and magnetite-series granites (Ishihara, 1977, 1981, 2004).

Ruttan Lake pluton (locality 2)

The Ruttan Lake pluton is a composite granitoid body ranging in composition from quartz monzonite to quartz diorite, granodiorite and granite. This pluton intruded supracrustal rocks of the 1883–1874 Ma Rusty Lake belt (Baldwin et al., 1987; Corrigan et al., 2009) of the LRD, which is host to the world-class Ruttan Cu-Zn deposit (Figure GS-10-2; Ames et al., 2002).

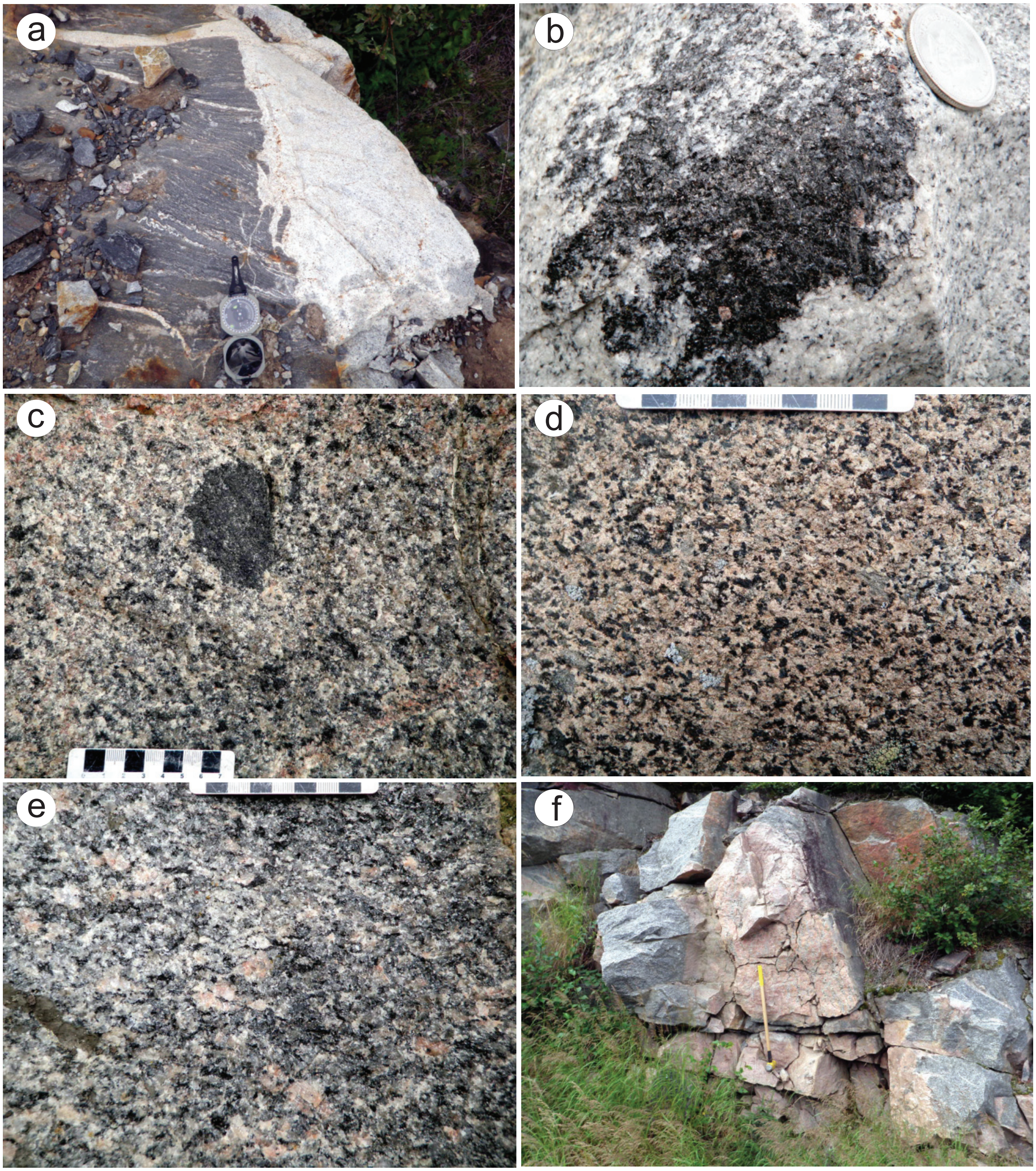

***Figure GS-10-3**: Field photographs of granitoid rocks from the Leaf Rapids domain: **a)** fine- to medium-grained biotite-muscovite granite, Issett Lake pluton (UTM Zone 14, 478927E, 6268920N, NAD 83), cutting sulphide-bearing gneissic metasedimentary rock; **b)** medium-grained granite (UTM same as photo a), containing metasedimentary xenoliths rich in biotite and garnet; **c)** medium- to coarse-grained granodiorite with fine-grained mafic inclusion, Issett Lake pluton (UTM 475813E, 6267785N); **d)** medium- to coarse-grained quartz monzonite, Ruttan Lake pluton (UTM 459422E, 6259658N); **e)** foliated porphyritic granodiorite, Turnbull Lake pluton (UTM 436557E, 6241927N); and **f)** pinkish, fine- to medium-grained granite cutting the porphyritic granodiorite, Turnbull Lake pluton (UTM same as photo e).*

The quartz monzonite is medium grey on fresh surface and weathers reddish grey (Figure GS-10-3d). It is medium to coarse grained, equigranular, massive and locally moderately foliated. It consists of 15–20% hornblende (3–5 mm), 5–10% biotite (3–5 mm), 25–30% plagioclase laths (3–5 mm) and 15–20% K-feldspar (4–5 mm). The quartz monzonite is cut by fine- to medium-grained granite, aplite and pegmatite dikes.

The granite is dominantly medium grained, equigranular and massive. It consists of 5–7% biotite flakes (1–2 mm), 25–30% anhedral quartz (2–4 mm), 30–40% K-feldspar (2–5 mm) and 15–20% plagioclase laths (2–4 mm) that display diffuse boundaries. Simple pegmatitic pods to dikes (composed mostly of feldspar, quartz and biotite±muscovite) occur locally in the granite. Also commonly seen are variably shaped xenoliths (e.g., elongate, irregular to subrounded) of greywacke, basalt and amphibolite up to 5 m across. Magnetic susceptibility values of the granite are relatively high, ranging from 2.44 to 10.6×10^{-3} SI, consistent with typical magnetite-series and I-type granites.

Turnbull Lake pluton (locality 3)

The Turnbull Lake pluton is emplaced into the southern portion of the LRD (Figure GS-10-2). It is composed dominantly of foliated porphyritic granodiorite that is cut by subordinate, fine- to medium-grained, pinkish equigranular granite to leucogranite (GS-10-3e, f). The porphyritic granodiorite is grey to pinkish grey and contains 5–10% megacrystic subhedral K-feldspar phenocrysts (20–30 mm in length; Figure GS-10-3e) in a medium- to coarse-grained groundmass composed of 10–15% biotite (5–10 mm), 1–5% hornblende (8–10 mm), 20–25% quartz (5–10 mm), 20–25% plagioclase laths (5–10 mm), 10–15% K-feldspar (5–10 mm) and minor magnetite (3–5 mm). A roughly east-west foliation trend is defined by aligned feldspars and biotite, generally parallelling the dominant, regional structural trend. The leucogranite is fine to medium grained, locally coarse grained, pinkish to pinkish red, massive and equigranular. It contains 2–5% biotite, 25–30% quartz, 40–50% K-feldspar and 5–10% plagioclase. The feldspar laths exhibit diffuse edges, indicative of sericitic and clay alteration.

Both the foliated granodiorite and massive leucogranite have relatively high MS values of $7.09–18.2 \times 10^{-3}$ SI, typical of magnetite-series and I-type granites. It is worth noting that this granite is similar to evolved I-type granites observed elsewhere, such as in the Lynn Lake greenstone belt (Yang and Beaumont-Smith, GS-9, this volume) and in the Appalachians of southwestern New Brunswick (Yang et al., 2008).

Granitoid rocks in the Kisseynew domain

Granitoid rocks examined and sampled in the Kisseynew domain (KD) include granodiorite to granite at Costello Lake (locality 4); garnet-bearing granodiorite of the Wapisu Lake intrusion (locality 5); and granodiorite to garnet-bearing granite and garnet-muscovite–bearing granite of the Notigi Lake intrusive suite (locality 6; Figure GS-10-2; Table GS-10-1).

Costello Lake pluton (locality 4)

The Costello Lake pluton comprises fairly homogeneous, massive and equigranular granite and granodiorite but displays relatively high MS values ($9.70–26.7 \times 10^{-3}$ SI) compared to other intrusive rocks in the KD (see below). The granite is fine grained and pinkish grey on both fresh and weathered surfaces (Figure GS-10-4a), and consists of 2–5% biotite (0.5–1 mm), 30–35% quartz (0.5–1.5 mm), 40–50% feldspar (1–3 mm) and 10–15% plagioclase (1–3 mm). Locally, it is cut by simple pegmatite dikes (composed of feldspar+quartz+biotite). The granodiorite (Figure GS-10-4b) is medium to coarse grained and grey to light pinkish grey, and consists of 10–15% biotite, 5–7% hornblende (2–4 mm), 20–25% quartz (3–5 mm), 35–40% plagioclase (4–6 mm) and 10–15% K-feldspar (3–5 mm). The mineral assemblages and MS values of both the granite and granodiorite in this pluton are clearly indicative of I-type and magnetite-series.

Wapisu Lake intrusion (locality 5)

The Wapisu Lake intrusion is a small stock comprising garnet-bearing granodiorite intruded into garnet-biotite-feldspar-quartz paragneiss to migmatitic rocks. The granodiorite is fine to locally medium grained, light grey, massive and equigranular. It is composed of 5% biotite (0.5–1 mm), 25%–30% quartz (0.5–1.5 mm), 45–55% feldspar laths (1–3 mm) that display diffuse edges, and minor pinkish-red euhedral garnet (1–3 mm). The granodiorite is cut by pegmatite dikes containing K-feldspar, quartz, garnet, biotite and local muscovite. It is worth noting that the Wapisu Lake granodiorite displays very low MS values of $0.046–0.079 \times 10^{-3}$ SI, suggesting that it represents peraluminous S-type granite (as defined by Chappell and White, 1974) and ilmenite-series granite (as defined by Ishihara, 1977), which is further evidenced by the presence of magmatic garnet.

Notigi Lake intrusive suite (locality 6)

Numerous dikes, plugs and small stocks of garnet-bearing granite, grouped into the Notigi Lake intrusive suite (NLIS), intrude paragneiss and migmatite of the Burntwood group (Murphy and Zwanzig, 2007). These granite bodies typically contain up to 5% pinkish to dark red garnet associated with 3–5% dark brown biotite and local minor muscovite. They occur as dikes ranging from a few centimetres to 10 m in width (Figure GS-10-4c) and are texturally heterogeneous (although massive and equigranular phases are also present), ranging from fine grained to pegmatitic (Figure GS-10-4d). Some of the

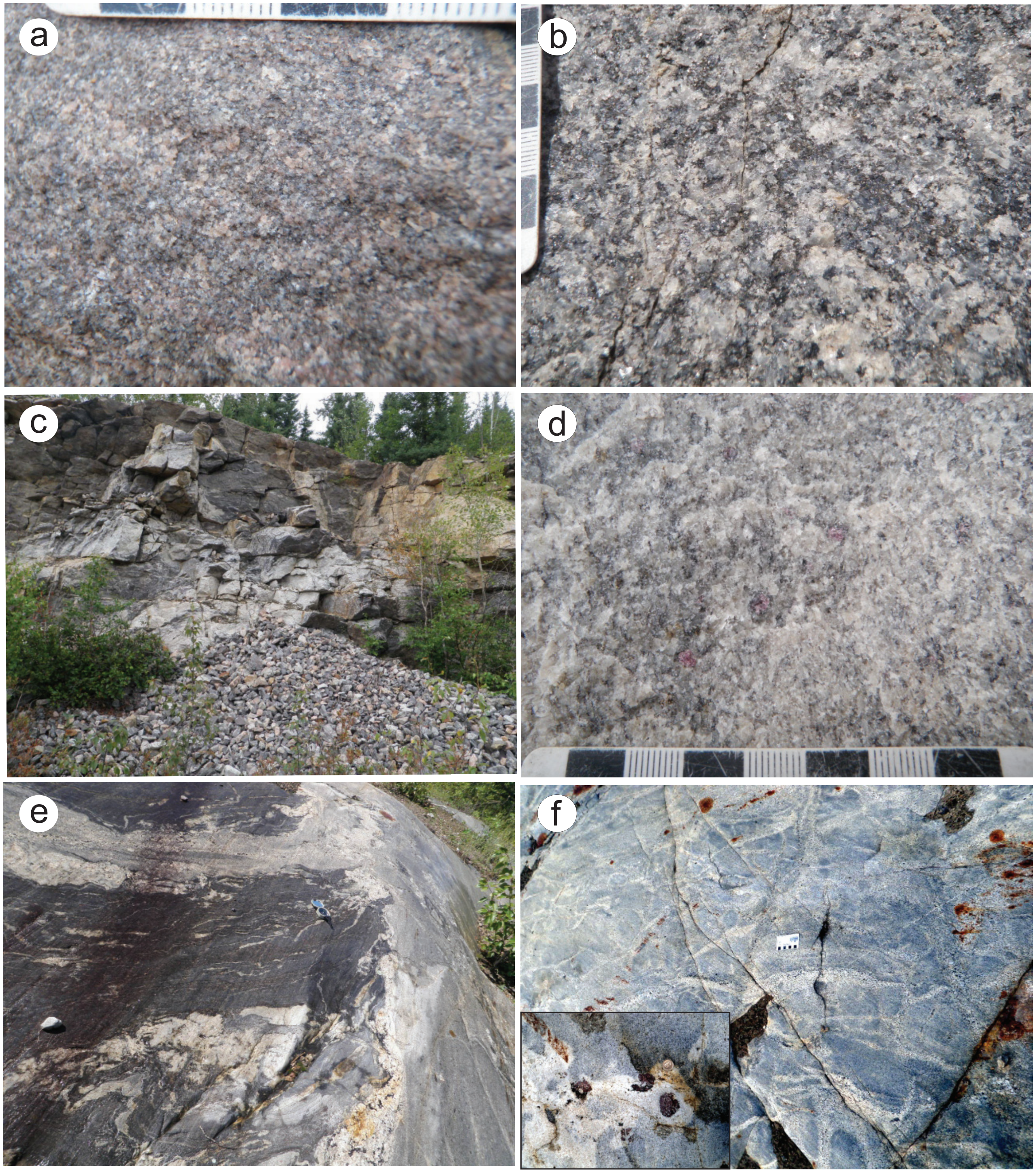

***Figure GS-10-4**: Field photographs of granitoid rocks from the Kisseynew domain: **a)** fine-grained granite, Costello Lake pluton (UTM Zone 14, 435867E, 5224857N, NAD 83); **b)** medium- to coarse-grained granodiorite, Costello Lake pluton (UTM 437743E, 6233556N); **c)** medium- to coarse-grained garnet-bearing granite dikes of the Notigi Lake intrusive suite intruding biotite-garnet-quartz-feldspar paragneiss (height of the quarry wall is about 8 m; UTM 477353E, 6189313N); **d)** medium-grained, massive, garnet-bearing granite (close-up the dike shown in photo c); **e)** medium- to coarse-grained to pegmatitic garnet-bearing granites (at least two phases) in gneissic to migmatitic protolith, Notigi Lake intrusive suite (UTM 474562E, 6189738N); **f)** medium-grained granodiorite intruded and fragmented by garnet-bearing pegmatitic granite, Notigi Lake intrusive suite (UTM 521718E, 6195505N); inset is an enlargement of the pale phase in veins or veinlets in the lower left corner, which contains garnet crystals larger than 1.5 cm.*

small intrusions display the coexistence of pegmatitic and medium- to coarse-grained phases (Figure GS-10-4e) that form a network of dike-like intrusions within the paragneiss and migmatitic rocks. This strongly suggests that these granitic melts may not have been transported very far from the source region (e.g., Brown, 2010) and clearly indicates that they are derived from partial melting of the metasedimentary rocks.

The NLIS granite bodies consist commonly of 30–35% quartz, 50–55% feldspars with diffuse crystal edges, 1–5% biotite, trace to 5% garnet, and local muscovite and trace sulphides, such as pyrite and pyrrhotite. Potassium feldspar is generally the dominant feldspar in the NLIS granitic phases, although granodiorite phases are also present. Granodiorite is medium grained, massive and equigranular, and contains 40–45% plagioclase (2–3 mm), 10–15% K-feldspar (2–4 mm), 25–30% quartz (2–3 mm) and 5–10% biotite flakes (2–3 mm). Local trace sulphide disseminations are evident, with notable presence of weakly magnetic pyrrhotite. Granodiorite is intruded, fragmented and brecciated by garnet-bearing coarse-grained to pegmatitic granite that seems to form networks on exposed surfaces (Figure GS-10-4f).

The NLIS granite and granodiorite phases display very low MS values, normally in the range 0.038–0.065 × 10^{-3} SI, which classifies them as peraluminous S-type (Chappell and White, 1974, 1992, 2001) and ilmenite-series granites (Ishihara, 1977, 1981, 2004). A few higher readings (up to 0.43 × 10^{-3} SI) are interpreted to be due to the presence of weakly magnetic pyrrhotite.

The NLIS described in this report does not include the alkaline, ca. 1885 Ma K-feldspar–phyric, monzonitic to syenogranitic suite (northeastern Kisseynew domain) at Footprint Lake described in Whalen et al. (2008). The Footprint Lake plutonic suite is interpreted to be formed by low-degree partial melting of subduction-modified subcontinental lithospheric mantle (Whalen et al., 2008).

Granitoid rocks in the Superior boundary zone (SBZ)

Granitoid rocks from the SBZ, including the Thompson, Split Lake and Assean Lake domains, are briefly described in this report, focusing on the Jock Lake, Orr Lake and Assean Lake intrusions and the Fox Lake pluton (localities 7–10, respectively, in Table GS-10-1 and Figure GS-10-2). Details about the nature and geological history of the SBZ, as well as its interaction with the Trans-Hudson orogen, have been discussed in many papers (e.g., Böhm et al., 1999, 2003; Corkery, 1985, 2000; Zwanzig et al., 2001, 2003; White et al., 2002; Corrigan et al., 2009; Kuiper et al., 2011).

Jock Lake intrusion (locality 7)

The Jock Lake intrusion cuts sulphide (e.g., pyrite and pyrrhotite)– and hornblende-bearing garnet-biotite-quartz-plagioclase paragneiss (Figure GS-10-5a). The main components of this intrusion are very coarse grained to pegmatitic granite and pegmatite that often occur as dikes cutting the paragneiss. The granitic rocks are massive and consist of quartz, K-feldspar and minor garnet, muscovite and local tourmaline. Graphic texture is common in the pegmatites, pointing to co-crystallization of quartz and K-feldspar. These granitic rocks are very low in MS (0.048–0.055 × 10^{-3} SI), indicative of S-type and ilmenite-series granites.

Orr Lake intrusion (locality 8)

Medium- to coarse-grained granitic gneiss (Figure GS-10-5b) is the dominant phase of the Orr Lake intrusion. The gneissosity (~240°/85°E) seems to parallel the main fabrics affected by the Trans-Hudson orogeny (e.g., Zwanzig et al., 2001), which may have curved around the promontory structure northeast of Thompson (Kuiper et al., 2011). This granitic gneiss shows strongly compositional layering, with apparent alternation of mafic- and felsic-enriched layers. It is noted that the layers rich in ferromagnesian minerals (biotite, ±hornblende±magnetite) display very high MS values of >30 × 10^{-3} SI, whereas layers rich in felsic minerals (quartz and feldspar) have low MS values of 0.5–1.5 × 10^{-3} SI. Overall, outcrops of the granitic rocks display MS values in the range 0.716–11.9 × 10^{-3} SI, consistent with I-type and magnetite-series granites elsewhere in the Superior province (e.g., Yang, 2014).

Assean Lake intrusion (locality 9)

Previous studies have indicated that several different types of granitoid intrusive rocks occur at Assean Lake, displaying a range of ages (e.g., Böhm et al., 2003). These granitoid rocks from the Assean Lake intrusion include strongly foliated to gneissic, medium- to coarse-grained, equigranular granodiorite to granite, and granitic orthogneiss. The granodiorite has compositional banding (Figure GS-10-5c) and consists of 5–10% biotite (±hornblende), 25–30% quartz (1–3 mm), 30–40% plagioclase (2–3 mm) and 10–15% K-feldspar (3–4 mm). Two groups of fabrics are evident: one trending ~090° overprinted by another trending ~070°. These fabrics are common in the SBZ, reflecting the older Archean east-trending structures overprinted by younger east-northeast-trending Paleoproterozoic structures (e.g., Corkery et al., 2000). The gneissic granodiorite and granite have MS values of 0.165–3.4 × 10^{-3} SI, consistent with I-type or magnetite-series granite (Table GS-10-1).

Fox Lake pluton (locality 10)

Granite in the Fox Lake pluton is texturally homogeneous, massive and medium to coarse grained, although the presence of variably foliated to mylonitic phases has been reported elsewhere (Corkery, 1985). The granitic

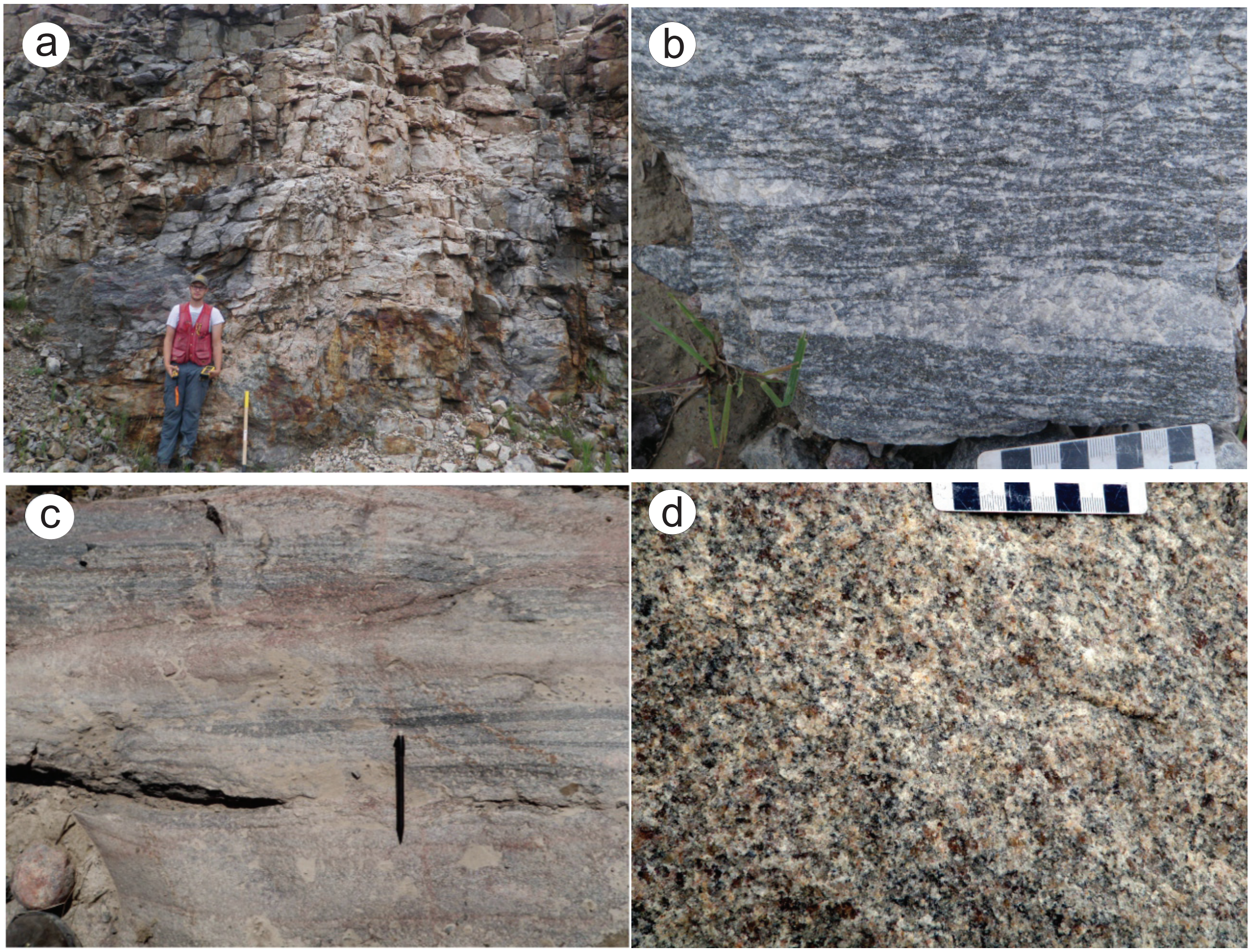

***Figure GS-10-5**: Field photographs of granitoid rocks from the Superior boundary zone: **a)** garnet-muscovite–bearing pegmatite and pegmatitic granite dike intrusive into paragneiss, Jock Lake intrusion (UTM Zone 14, 557399E, 6191948N, NAD 83); **b)** medium-grained granite gneiss, Orr Lake intrusion (UTM 619820E, 6213084N); **c)** medium-grained gneissic granodiorite, Assean Lake intrusion (UTM 637210E, 6224513N); and **d)** medium- to coarse-grained, massive biotite granite, Fox Lake pluton (UTM 682470E, 6244232N).*

body is pinkish grey to light grey on fresh and weathered surfaces (Figure GS-10-5d) and comprises 4–7% biotite (3–4 mm), 30–35% anhedral quartz (4–6 mm), 40–50% K-feldspar laths (5–7 mm) and 10–15% plagioclase (2–7 mm). Feldspars display diffuse edges, likely related to sericitic alteration. The lack of foliation or gneissosity in this pluton suggests it may be later than the Orr Lake and Assean Lake intrusions described above. This granite has low MS values ($<0.088 \times 10^{-3}$ SI), suggesting that it is an ilmenite-series granite. Biotite is the only ferromagnesian mineral in this granite, and hornblende is absent. Pending whole-rock geochemistry results (or, alternatively, results from biotite chemistry) will aid in determining if this granite belongs to the S or I classification.

Economic considerations

Different types of granitoid rocks have been identified in the Leaf Rapids domain, Kisseynew domain and Superior boundary zone from north-central Manitoba, providing the first-order criteria for evaluation of their mineral potential and tectonic settings. Building on previous studies by various authors, new petrographic information has been acquired during this reconnaissance mapping and sampling project. However, systematic, laboratory-based petrographic, lithogeochemical and petrological studies are needed to provide additional constraints on the sources, geotectonic settings, magmatic processes and metallogeny of these granitoid rocks.

The preliminary results reveal that muscovite- and/or garnet-bearing granitic rocks (i.e., strongly peraluminous or S-type granitoid rocks) with commonly low MS values ($<0.1 \times 10^{-3}$ SI) are intruded mainly into terrane boundaries, thus providing a macro-recognizable geological criterion to assist in the subdivision of tectonic units in the region. Peraluminous granitoid rocks typically form in tectonically thickened crust due to continental collision, are often associated with pegmatite intrusions enriched in rare metals and may have potential to host

Sn-W mineralization. I-type granitoid plutons, consisting of quartz diorite, tonalite, granodiorite and granite, contribute to the growth of continental crustal at subduction margins. These types of granitoid plutons and batholiths host important deposits of Cu, Au and Mo in many orogenic belts. Evolved I-type granite may have potential for rare-metal (e.g., Nb, Ta) minerals.

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